PATENT SPECIFICATION

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488,571

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Complete Specification Accepted: July 11, 1938.

PROVISIONAL SPECIFICATION

Improvements in Plate Heat Exchangers for Fluids

We, ANDREW SWAN and ALAN ARNOLD GRIFFITH, both of the Royal Aircraft Establishment, South Farnborough, Hampshire, British subjects, do hereby declare the nature of this invention to be as follows:—

This invention relates to heat exchangers for fluids in which the fluid passages are formed by corrugated plates or sheets placed between flat plates or sheets, and in which the two fluids, one to be cooled the other to be heated, pass through the exchanger in different directions.

According to the present invention, the heat exchanger is constructed of zig-zag or corrugated (hereinafter referred to as corrugated) plates or sheets (hereinafter referred to as sheets) which are arranged with corrugations in some of the sheets at an angle to the corrugations in others of the sheets and of flat plates or sheets (hereinafter referred to as sheets) arranged one between each two adjacent corrugated sheets, all the sheets being coated with solder, tin, or other metal (which process is hereinafter referred to as tinning) prior to assembly and being joined by heating and merging of the tinned surfaces (which process is hereinafter referred to as sweating) at the contacting parts of adjacent sheets after assembly to form a rigid pack or matrix (hereinafter referred to as a matrix). The matrix may be mounted in a surrounding or skeleton frame. In one arrangement, the corrugations in any one sheet are at an angle to those in the adjacent sheet or sheets, while the corrugations in alternate sheets are parallel to one another.

Another feature of the invention is that the flat and corrugated sheets may be made of very thin material, and the corrugations may be of small dimensions.

Another feature of the invention is that the corrugations forming the passages for the flow of one fluid may be of the same or different dimensions from the corrugations forming the passages for the flow of the other fluid.

Another feature of the invention is that the dimensions of the corrugations of the sheets may be chosen in regard to the thickness of the sheet such that the part of the corrugated sheet extending between the flat sheets becomes a fin of high heat dissipating qualities.

Another feature of the invention is that each corrugated sheet is shaped along the two outer marginal parts parallel to the direction of the corrugations, so that when the exchanger is assembled and the whole sweated together there is a definite seal along these marginal parts to prevent leakage of the fluids.

Another feature of the invention is that the marginal parts of each corrugated sheet are made to extend between adjacent flat sheets to form a surface of stream-line shape projecting beyond the entrances and exits of the adjacent corrugated sheets, so as to reduce the entry and exit losses through the passages.

Another feature of the invention is that the marginal parts of the flat sheets on all sides are shaped and bent so that when the exchanger is completely assembled and sweated together two opposite edges of one flat sheet meet and are sweated to the two corresponding edges of the flat sheet which adjoins on one side, while the other two edges of the first flat sheet meet and are sweated to the two corresponding edges of the flat sheet which adjoins on the other side.

Another feature of the invention is that wires or strips are fitted between the edges of adjacent flat sheets and lie parallel to and adjoining the corrugations of the corrugated sheet between the adjacent flat sheets and are sweated in this position to form a stream-line surface.

Another feature of the invention is that angle pieces forming a skeleton frame are soldered along the four corners of the assembled matrix at right angles to the plane of the flat and corrugated sheets to form a seal at these corners between the passages for one fluid and those for the other fluid.

The heat exchanger, according to one form of construction, comprises a number of parallel flat sheets between each two of which is inserted a corrugated sheet in such a manner that the corrugations in each alternate corrugated sheet run in the

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same direction, but the corrugations of two adjacent corrugated sheets do not run in a similar direction but in some other direction, for example at right angles.

The flat and corrugated sheets may be of thin material of the order of .002 in. or .003 in., although they may be less or more than this thickness, and are constructed of a material which can be tinned, such as copper, brass, german silver, cupro-nickel, stainless iron, or stainless steel.

The sheets or the strips from which the sheets are to be cut are tinned all over. The strips are then cut to provide the necessary flat sheets, while other strips are corrugated and cut to size. The corrugations may be of triangular form with sharp or blunt apices, or the corrugations may be of curved or sinusoidal form. A suitable dimension for depth of corrugation may be 30 times the thickness of the sheets, but other dimensions may be used. When a corrugated sheet is cut to the shape desired, the last corrugation, or more if necessary, is bent flat so that when the heat exchanger is assembled the flat marginal part will press against a flat sheet to make a good joint and seal when eventually sweated.

The flat and corrugated sheets are then assembled in a jig or frame, starting with a flat sheet, then a corrugated sheet with the corrugations running in the desired direction, then a flat sheet and another corrugated sheet with the corrugations running in the other direction, for example at right angles to the first direction, and so on until the necessary size of exchanger is made up. The exchanger, when fully assembled, is tightened up in the jig, coated by or dipped in a suitable flux, placed in an oven at the requisite temperature, and sweated together at all points of contact between the sheets. The tightening up in the jig ensures that contact is made between the flat sheets and all the apices of the corrugated sheets, and also between the flat marginal parts of the corrugated sheets with the flat sheets to provide a seal.

A modification of the above construction to reduce entry and exit losses through the exchanger may be obtained by shaping the last corrugation or more not only to provide the flat marginal part for sweating to one adjacent flat sheet, as previously described, but also to curve round and extend to the other adjacent flat sheet so as to form a stream-line surface, the edge of the curved portion being sweated to the latter flat sheet.

An alternative to the construction described in the previous paragraph is obtained by cutting the flat sheets to a greater size than the size of the exchange proper and turning two opposite edges downward to an extent slightly greater than half the depth of the corrugation of a corrugated sheet on one side, and the other two opposite edges upward to an extent slightly greater than half the depth of the corrugation of the corrugated sheet on the other side. The flat sheets are assembled with the corrugated plates, as previously described, in such a manner that the corresponding edges of adjoining flat sheets meet and press against each other so that they may be finally sweated together to form a stream-line surface.

Another alternative to the construction described in the previous paragraph is obtained by fitting wires or strips between the flat sheets and parallel to the corrugations in such a manner that part of the wires or strips project beyond the surface of the exchanger to provide stream-line surfaces.

The corners of the flat or corrugated sheets are cut away, or the length of the wires are such that angle pieces may be soldered along the four corners of the assembled heat exchanger at right angles to the flat and corrugated sheets. Suitable inlet and outlet casings are fitted.

Dated this 9th day of January, 1937.
ANDREW SWAN,
ALAN ARNOLD GRIFFITH.
Applicants.

COMPLETE SPECIFICATION

Improvements in Plate Heat Exchangers for Fluids

We, ANDREW SWAN and ALAN ARNOLD GRIFFITH, both of the Royal Aircraft Establishment, South Farnborough, Hampshire, British subjects, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to heat exchangers for fluids in which the fluid passages are formed by corrugated plates or sheets placed between flat plates or sheets.

According to the present invention, the heat exchanger is formed of flat plates or sheets (hereinafter referred to as sheets) and of zig zag or corrugated (hereinafter referred to as corrugated) plates or sheets (hereinafter referred to as sheets) arranged

one between each two adjacent flat sheets, all points and surfaces of contact of the sheets being joined together in metallic union to form a rigid whole. In one method of securing metallic union all the sheets are coated with a suitable material such as solder, tin, or other metal (which process is hereinafter referred to as tinning) prior to assembly and are joined in metallic union (which process is hereinafter referred to as sweating) at the contacting parts of adjacent sheets after assembly to form a rigid pack or matrix (hereinafter referred to as a matrix). The matrix may be mounted in a surrounding frame and suitable inlets and outlets for the passage of the fluids may be fitted.

In one arrangement of the matrix, the corrugations in alternate corrugated sheets are parallel to one another, while the corrugations in adjacent corrugated sheets are at an angle to one another.

A feature of the invention is that the flat and corrugated sheets may be made of very thin material of the order of 0.002 in. thick, although they may be less or more than this, and are constructed of a material which can be tinned such as copper, brass, german silver, cupro nickel, stainless iron, or stainless steel.

Another feature of the invention is that the corrugations of the corrugated sheets may be of small dimensions, may be of triangular form with sharp or blunt apices or may be of curved or sinusoidal form, and the dimensions of the corrugations may be chosen in regard to the thickness of the sheet such that the part of the corrugated sheet extending between the flat sheets becomes a fin of high heat dissipating qualities. A suitable dimension for the depth of corrugation may be from 10 to 30 times the thickness of the sheets, but other dimensions may be used.

Another feature of the invention is that the corrugations of the corrugated sheets may be of the same or of different dimensions.

Another feature of the invention is that the sides of the matrix may be provided with stream-line surfaces between each two adjacent flat sheets, parallel to the direction of the corrugations of the corrugated sheet lying between, so as to reduce entry and exit losses through the heat exchanger.

Another feature of the invention is that a seal to prevent leakage of the fluids may be provided along the marginal parts between each two adjacent flat sheets parallel to the direction of the corrugations of the corrugated sheet lying between.

Another feature of the invention is that pieces may be fixed along the four corners of the assembled matrix at right angles to the plane of the flat and corrugated sheets to form a seal at these corners.

According to another feature of the invention, the matrix may be sub-divided so that either or both fluids may be constrained to pass two or more times through successive sets of the appropriate corrugated passages, successive passes being in opposite directions. Where this feature is applied to both fluids the arrangement is such that the fluids pass in a contraflow direction.

The heat exchanger, according to one form of construction, comprises a number of parallel flat sheets between each two of which is inserted a corrugated sheet in such a manner that the corrugations in alternate corrugated sheets run in the same direction, but the corrugations of adjacent corrugated sheets are at right angles to one another.

The material for the sheets is tinned all over, and part is cut into flat sheets of the requisite size while part is corrugated and cut to size. The flat sheets are cut to a greater size, except at the four corners, than the size of the exchange proper, and two opposite edges are turned downward to an extent approximately equal to the depth of the corrugation of a corrugated sheet on one side and the other two opposite edges turned upward to an extent approximately equal to the depth of the corrugation of the corrugated sheet on the other side, these edges being curved to a circular form.

The heat exchanger is assembled in the following manner. For the bottom a flat sheet of greater thickness is used to provide stiffness to the matrix, next follows a flat sheet with two opposite turned up edges into which is fitted one corrugated sheet with the corrugations running parallel to the turned up edges, next follows a flat sheet with two opposite edges turned down and the other two opposite edges turned up, which is fitted on top of the flat sheet already assembled in such a manner that the two opposite and curved edges of the two flat sheets overlap. On top of the second flat sheet and between the upward curved edges is fitted a corrugated sheet at right angles to the first corrugated sheet. This procedure is continued until the necessary size of matrix is obtained and is finished with a flat sheet with only two opposite turned down curved edges, and finally a thicker flat sheet to provide the necessary stiffness.

The matrix when fully assembled is fitted into and tightened up in a jig, with

angle pieces inserted to fit along each of the four corners. The matrix is then coated with or dipped in a suitable flux, placed in an oven at the requisite temperature, and sweated together at all points of contact between the sheets. Tightening up in the jig ensures that contact is made between the flat sheets and all the apices of the corrugated sheets and also between the marginal parts of the flat sheets with one another and the sweating together of the contacting points and surfaces will ensure metallic union of the various surfaces, will seal the marginal parts and will provide stream-line surfaces to reduce entry and exit losses through the exchanger. A matrix of high rigidity and high heat dissipating qualities is thus obtained.

The heat exchanger is then fitted with suitable inlet and outlet headers to permit the passage of the fluids.

In an alternative form of construction the tinned corrugated and flat sheets are cut to the exact size of the exchanger, no curved pieces being provided on the edges of the flat sheets. Assembly of the exchanger is made by inserting flat and corrugated sheets alternately into the jig, the corrugations in adjacent corrugated sheets being arranged at right angles to one another, fixing angle pieces at the four corners, tightening up the matrix in the jig, covering with flux and sweating the whole together.

Sealing wires or strips of stream-lined shape are soldered or otherwise fixed between each pair of adjacent flat sheets parallel to and adjoining the corrugations of the corrugated sheets lying between, and suitable inlet and outlet headers are fitted.

One form of the invention is illustrated in the accompanying drawings, in which Fig. 1 is a part section view of a heat exchanger, Fig. 2 a view showing an assembly of the flat and corrugated sheets, Fig. 3 a view of a sealing piece suitable for the four corners of the heat exchanger, and Figs. 4 and 5 are views of flat sheets showing the curved edges. Figs. 6 and 7 show an arrangement of the invention in which each fluid passes twice through the matrix. Figs. 8 and 9 are views of a suitable assembly jig.

Fig. 1 shows a matrix 1 composed of alternate flat sheets 2 and corrugated sheets 3 layered so that the corrugations of alternate corrugated sheets run in the same direction but those of adjacent corrugated sheets run at right angles to one another. The matrix 1 is fitted at the corners with angle pieces 4 and headers 5 are fitted to permit the entry and exit of one fluid.

In Fig. 2 adjacent corrugated sheets 3 are shown running at right angles to one another between flat sheets 2, the curved portions 6 of the flat sheets providing a stream-line entry to the corrugated passages.

Fig. 3 shows an example of angle piece 4 for fitting along the four corners of the matrix to provide a seal between the corrugations of adjacent corrugated sheets 3 in Fig. 2.

In Figs. 4 and 5 the alternate flat sheets 2 are curved at the edges 6 so that when fitted together the curved edges overlap and form a stream-lined surface.

In Figs. 6 and 7 one fluid enters the matrix 1 by header 7 and passes through part of the matrix to header 8 and from there to the other part of the matrix and leaves by header 9, the flow through the two parts of the matrix being in opposite directions. The other fluid enters the matrix 1 by header 10 and passes through part of the matrix to header 11 and from there to the other part of the matrix and leaves by header 12, the flow through the two parts of the matrix being in opposite directions.

The jig, Figs. 8 and 9, consists of a rectangular shaped box 13 having two opposite ends open which are covered by cover plates 14 held on by screws or bolts 15.

The walls of the box and the attached covers are apertured in many places such as at 16 to give access to the hot fumes while the jig is in the oven.

Three mutually adjacent walls of the jig are fitted with spring loaded following up face plates 17. The springs 18 are adjustable for load by the screws 19 which register with the cylindrical shanks 20 of the face plates. The face plates are prevented from turning round the axis of the shanks 20 by one or more edges being adjacent to a wall of the box such as at 21. Angle pieces 4 (Figs. 1 and 3) for fitting along the four corners of the matrix are shown in place in the jig.

The parts of the jig in contact with the matrix are preferably made of a material that is not readily sweated.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A heat exchanger for fluids constructed of alternate flat and corrugated sheets, all points and surfaces of contact of the sheets being joined together in metallic union to form a rigid whole.

2. A heat exchanger as claimed in claim (1), wherein the corrugations in some of the currugated sheets are parallel

to one another but at an angle to the corrugations of the other corrugated sheets.

3. A heat exchanger as claimed in claim (1), wherein the corrugations in alternate corrugated sheets are paralle. to one another, while the corrugations in adjacent corrugated sheets are at right angles to one another.

4. A heat exchanger as claimed in any of the preceding claims, wherein the flat and corrugated sheets are made of a very thin material and the corrugations are of small dimensions.

5. A heat exchanger as claimed in any of the preceding claims, wherein the corrugations in the different plates forming the passages for the fluids are of the same dimensions.

6. A heat exchanger as claimed in any of the preceding claims, wherein the corrugations in the different plates forming the passages for the fluids are of different dimensions.

7. A heat exchanger as claimed in any of the preceding claims, in which the sides of the matrix are provided with stream-line surfaces between each two adjacent flat sheets, parallel to the direction of the corrugations of the corrugated sheet between such two adjacent flat sheets.

8. A heat exchanger as claimed in any of the preceding claims, in which a seal to prevent leakage of fluid is provided along the marginal parts between each two adjacent flat sheets parallel to the direction of the corrugations of the corrugated sheet lying between such two adjacent flat sheets.

9. A heat exchanger as claimed in any of the preceding claims, wherein pieces are fixed along the four corners of the assembled matrix at right angles to the plane of the flat and corrugated sheets to form a seal at these corners.

10. A heat exchanger, as claimed in any of the preceding claims, in which the matrix is sub-divided so that either or both fluids may be constrained to pass two or more times through successive sets of the appropriate corrugated passages, successive passes being in opposite directions.

11. A heat exchanger as claimed in claim 10, in which the two fluids pass in a contraflow direction.

12. Heat exchangers constructed substantially as described with reference to and as shown in Figs. 1 to 7 of the accompanying drawings.

13. The method of making a heat exchanger as claimed in any of the preceding claims, in which the sheets are assembled in a jig and heated to obtain metallic union of the contacting parts.

14. A jig when used in constructing a heat exchanger according to the method claimed in claim 13 constructed substantially as described with reference to Figs. 8 and 9 of the accompanying drawings.

Dated this 8th day of January, 1938.

ANDREW SWAN,
ALAN ARNOLD GRIFFITH,
Applicants.

Leamington Spa: Printed for His Majesty's Stationery Office, by the Courier Press.—1938.

[This Drawing is a reproduction of the Original on a reduced scale.]

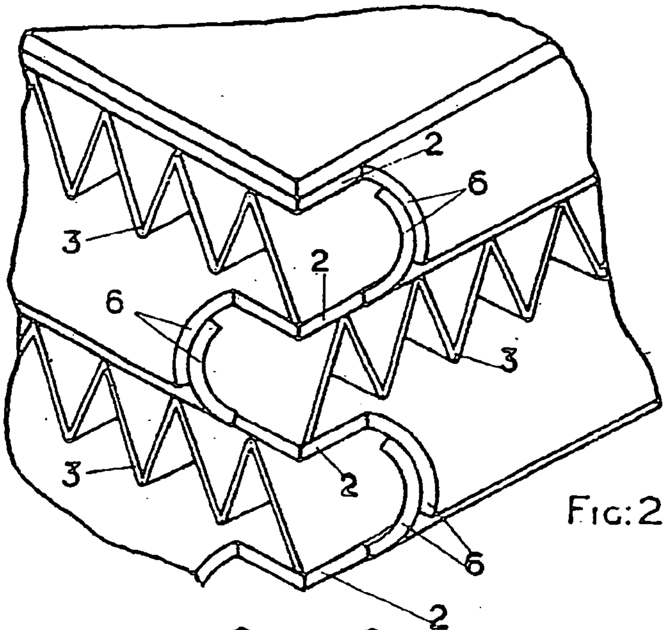

FIG: 2.

FIG: 4

FIG: 5.

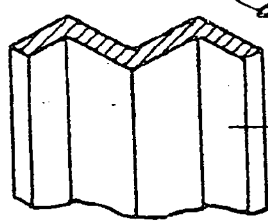

FIG: 3.

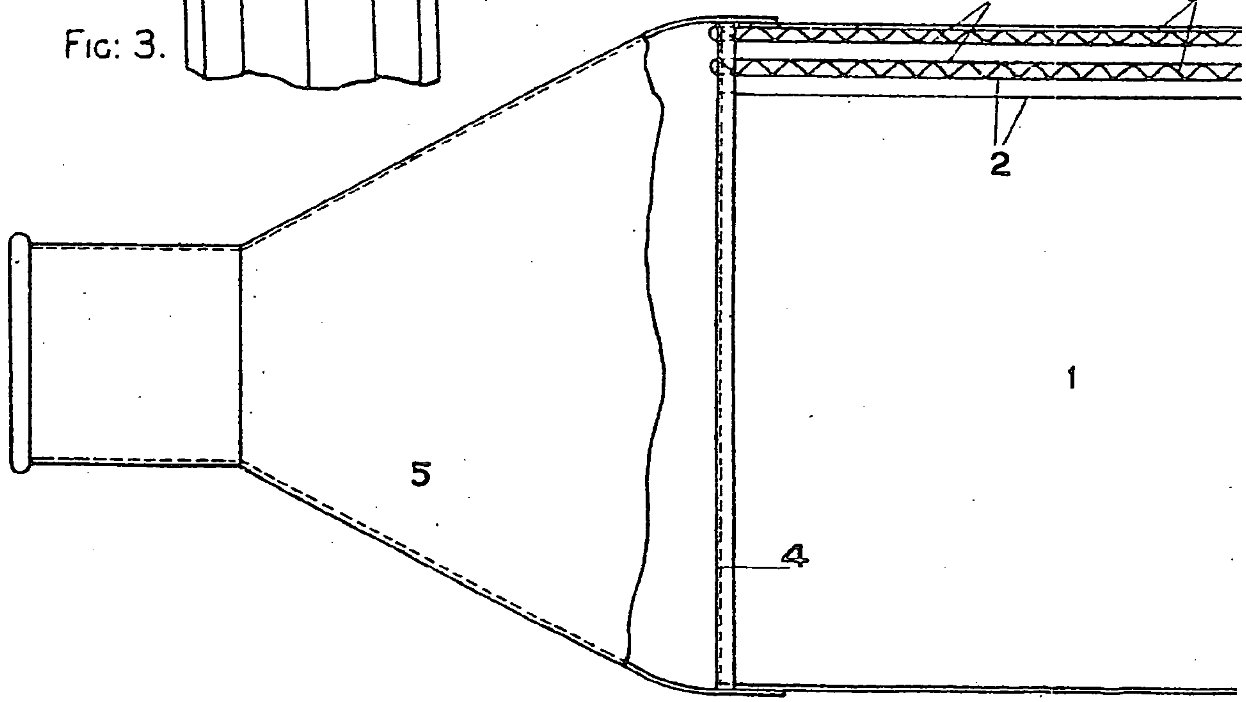

FIG: 1.

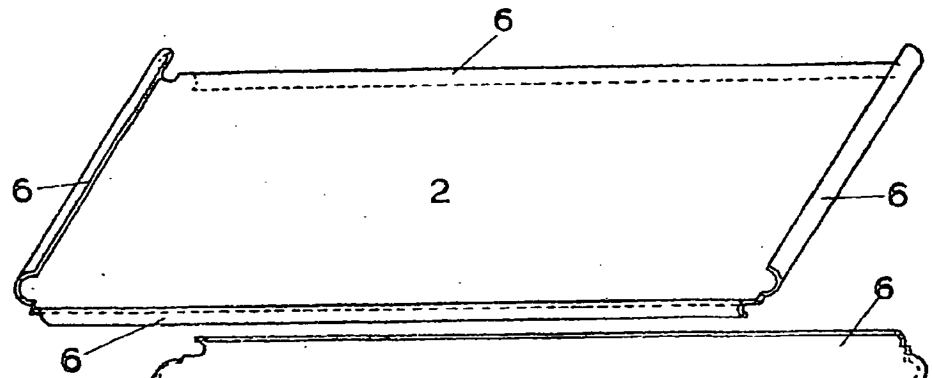

FIG: 4.

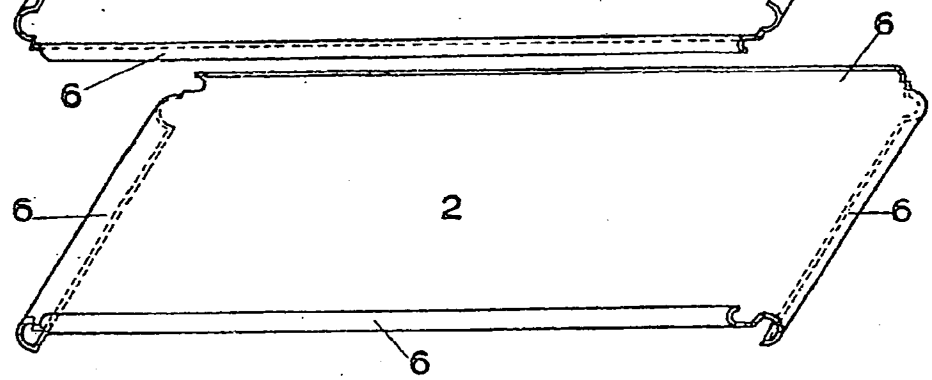

FIG: 5.

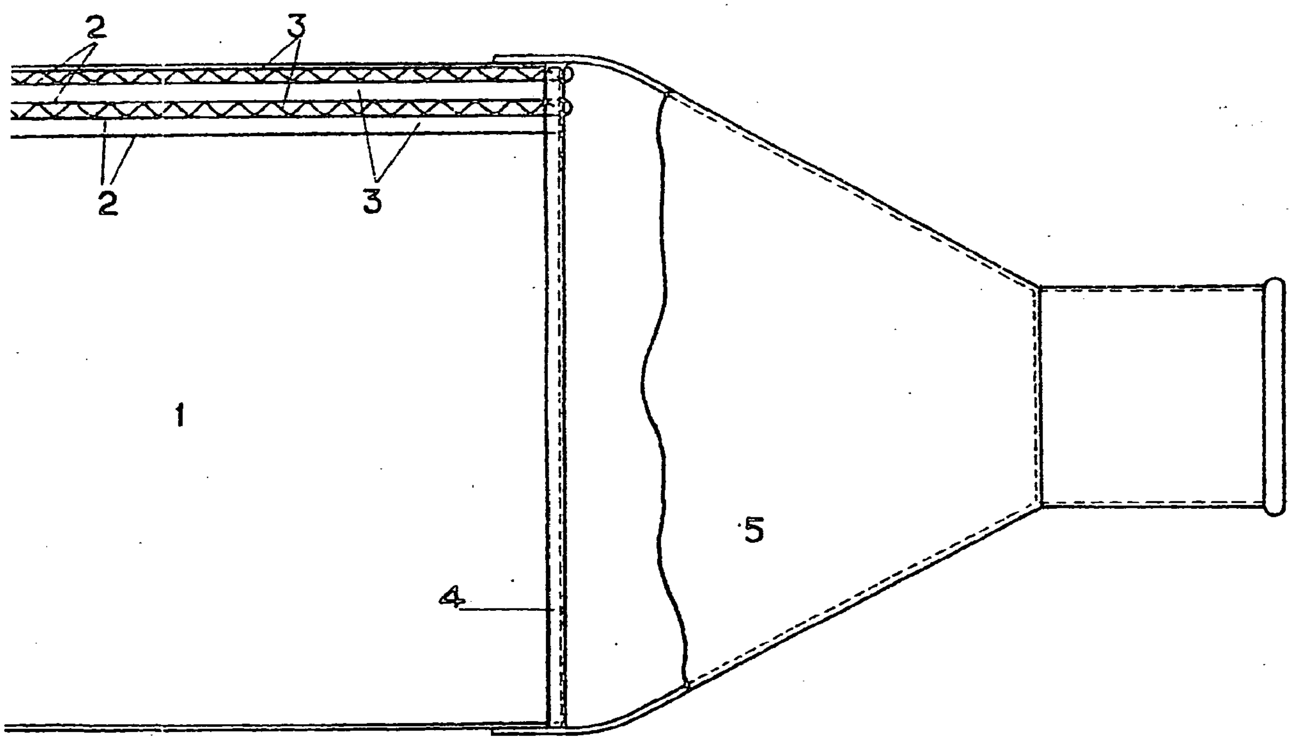

FIG: 1.

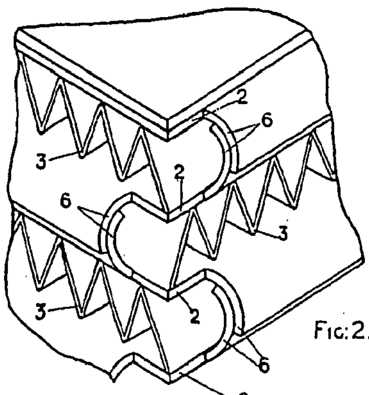

Fig: 2.

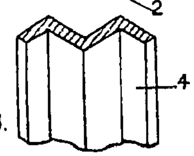

Fig: 3.

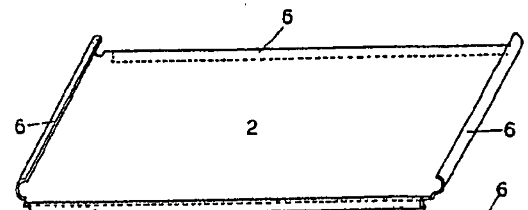

Fig: 4.

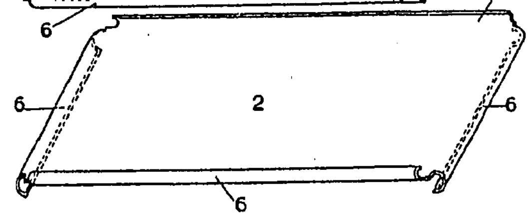

Fig: 5.

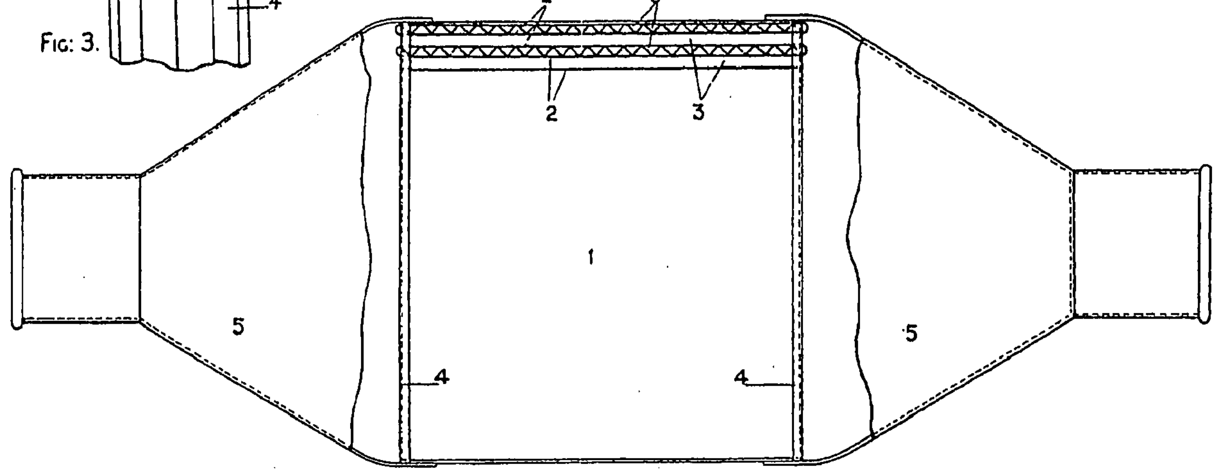

Fig: 1.

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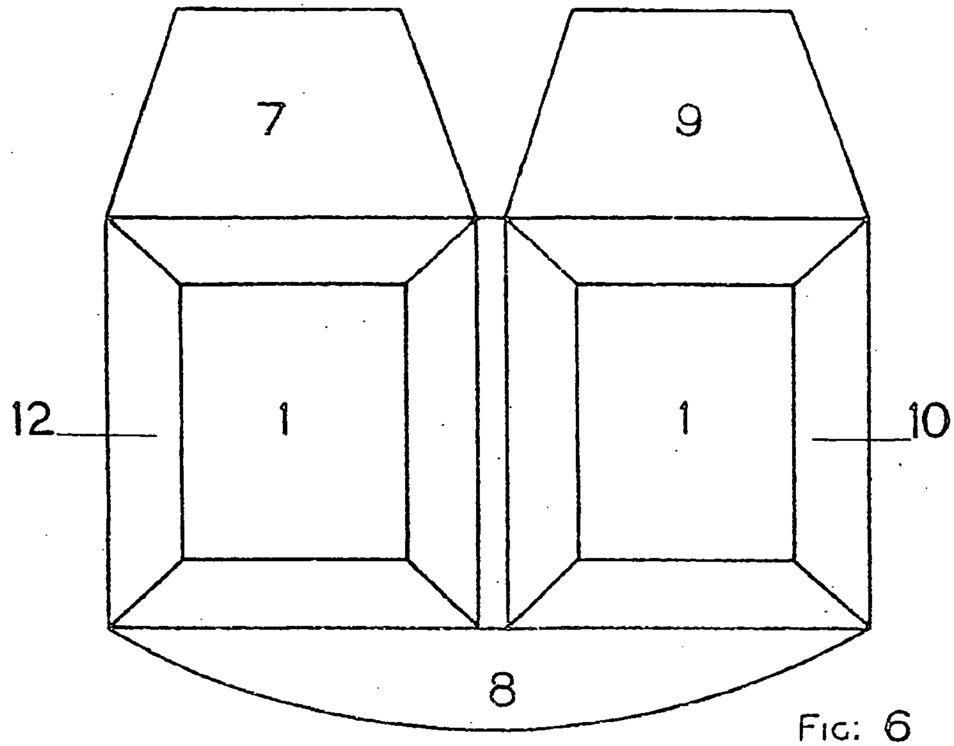

FIG: 6

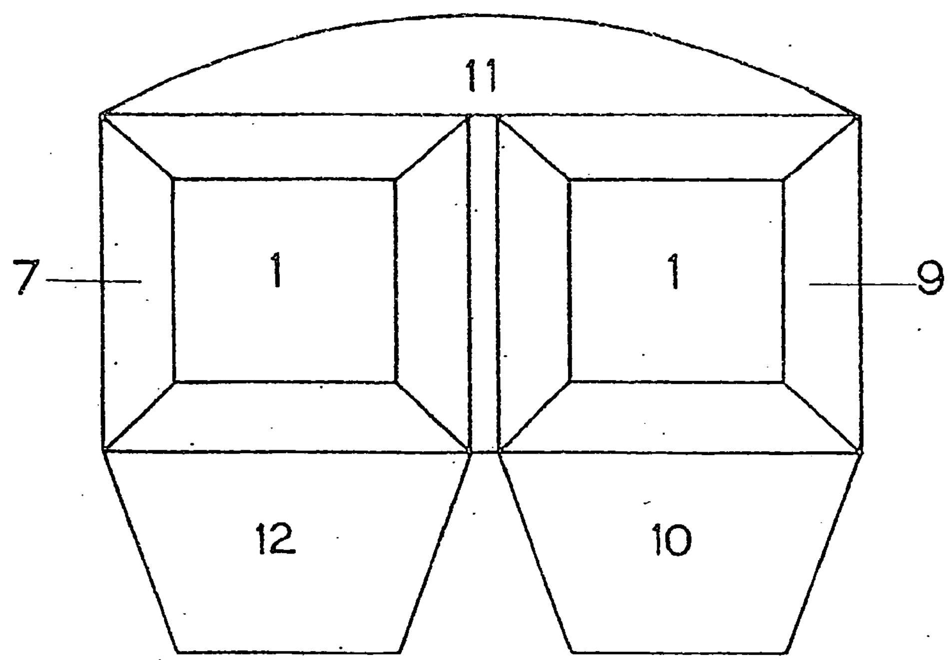

FIG: 7

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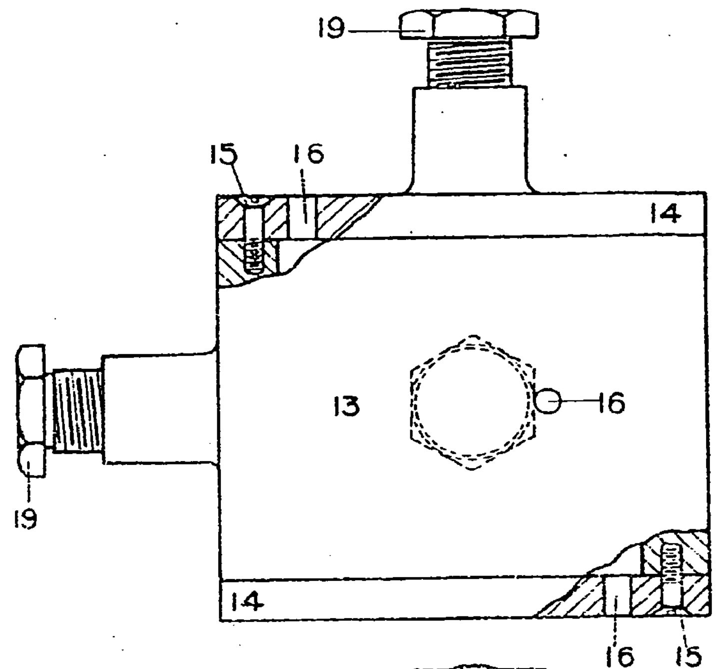

Fig: 8.

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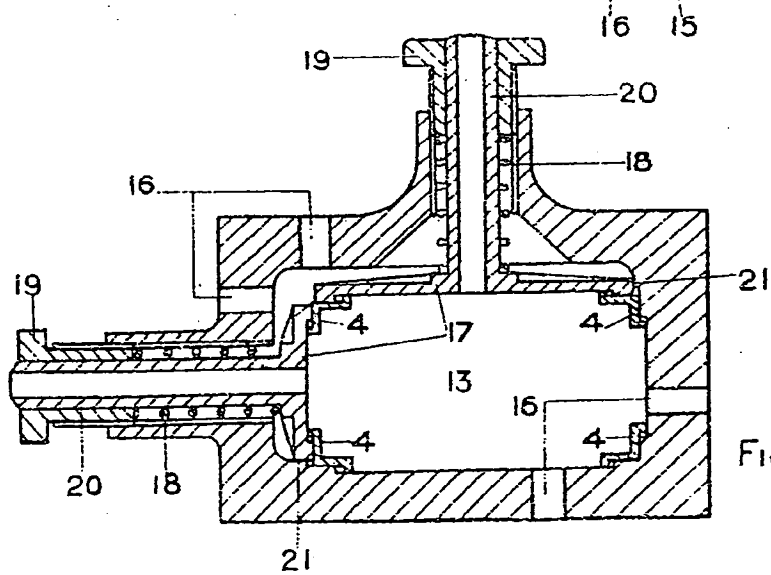

Fig: 9.

Malby & Sons, Photo-Litho

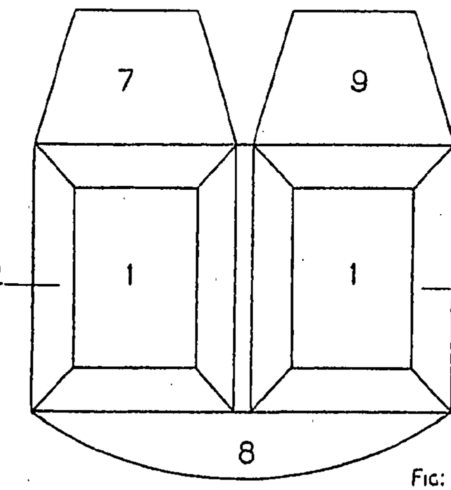

Fig: 6

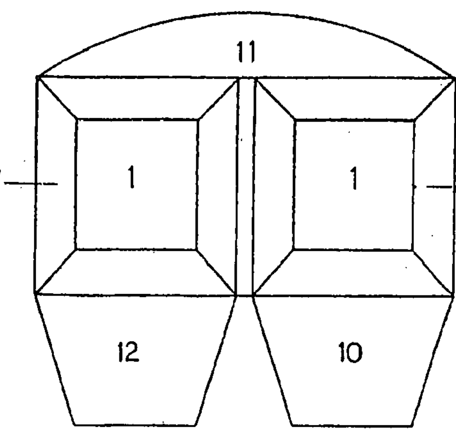

Fig: 7

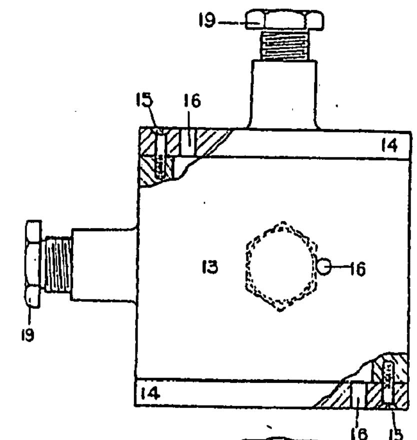

Fig: 8.

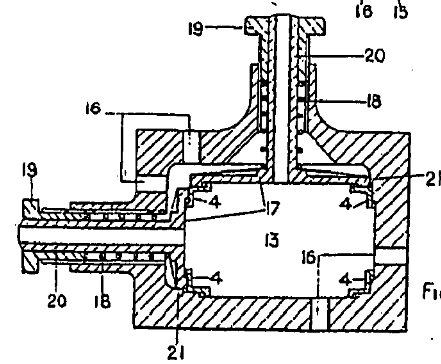

Fig: 9.

[This Drawing is a reproduction of the Original on a reduced scale.]